SECTION 17- DOUBLE GIMBALED STRING POTENTIOMETER (DGSP) UNITS

17.1 DGSP Unit Description and Features

The lower abdominal component uses two devices to measure the penetration of the abdomen. These deflection devices are referred to as double gimbaled string potentiometer (DGSP) sensors. The individual sensors on the DGSPs allow measurements of linear displacement along the axis of the telescopic columns, and rotations around two orthogonal axes. These three degrees of freedom are used for determining the three-dimensional coordinates of the telescope's end point. Connected to a high-speed data acquisition system, the instrumentation can be used to record the time history of an abdominal penetration during an impact test.

Figure 17.1 shows a detail drawing of the various parts of a DGSP unit for reference. The DGSP base is attached to the lower abdomen mounting bracket which bolts to the spine assembly. The DGSP U-joint assembly is mounted to the front of the lower abdomen assembly.

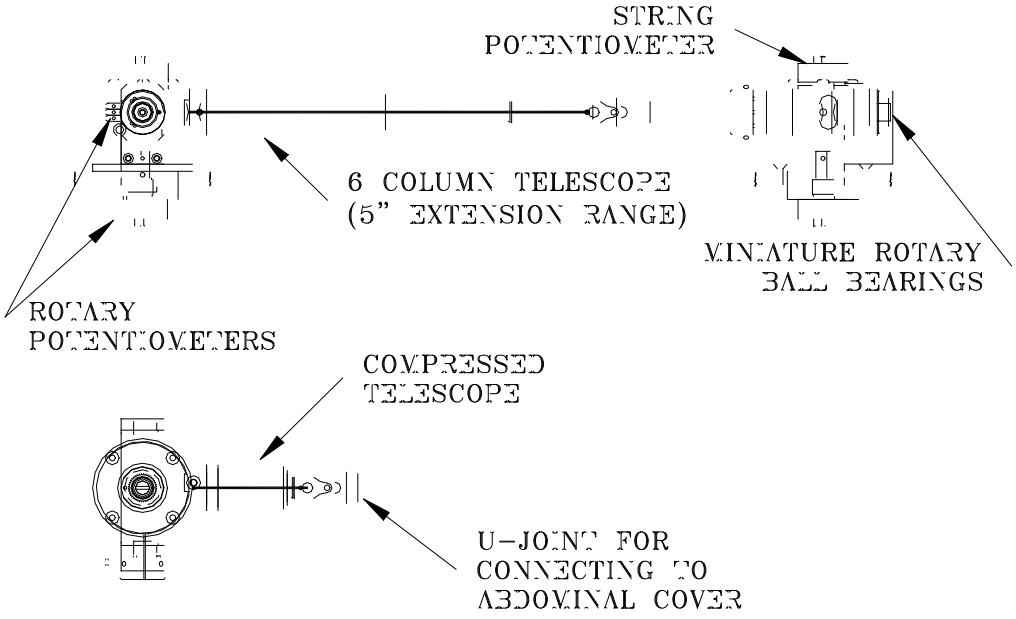

Figure 17.1- DGSP assembly

The DGSP sensor includes a string transducer and two rotary potentiometers. The string transducer measures the rotation of a drum as the cable coils and uncoils. The cable's inherent lack of rigidity required a series of telescoping columns. The columns reduce the cable's motion to a linear travel. The telescope and the potentiometer are assembled together and mounted on a double-gimbaled yoke. Two rotary potentiometers mounted in the gimbals measure the rotations of the orthogonal axes. The translational and rotational freedom of the yoke allows the end point

of the telescope to sweep through a large volume of three-dimensional space.

The DGSP units are calibrated prior to insertion within the dummy's lower abdomen. Once the calibration has been performed, the unit may be inserted and tested up to 25 times before recalibrating. (Note: If damage or suspicious output is discovered at any time during testing, the units should be recalibrated.) During the calibration procedure, the output voltage from each of the three potentiometers is measured and recorded for various angular orientations of the unit. This calibration information is used to define the calibration and setup variables in the input parameter file to be used with the THORTEST software program. During impact testing, the output voltages from each of the three potentiometers are recorded with a data acquisition system. This data is processed post-test using the THORTEST program to convert the output voltages into actual three-dimensional coordinates (X, Y, Z displacement). Thus the initial, dynamic, and final positions of the unit can be determined directly from the potentiometer output voltage signals.

17.2 Assembling DGSP Units

17.2.1 Parts List

The parts list and all quantities for the DGSP assembly are listed in Appendix I - Bill of Materials under the DGSP subsection. Refer to drawing T1DPM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 17.2** is a photograph of the exploded DGSP units and mounting hardware.

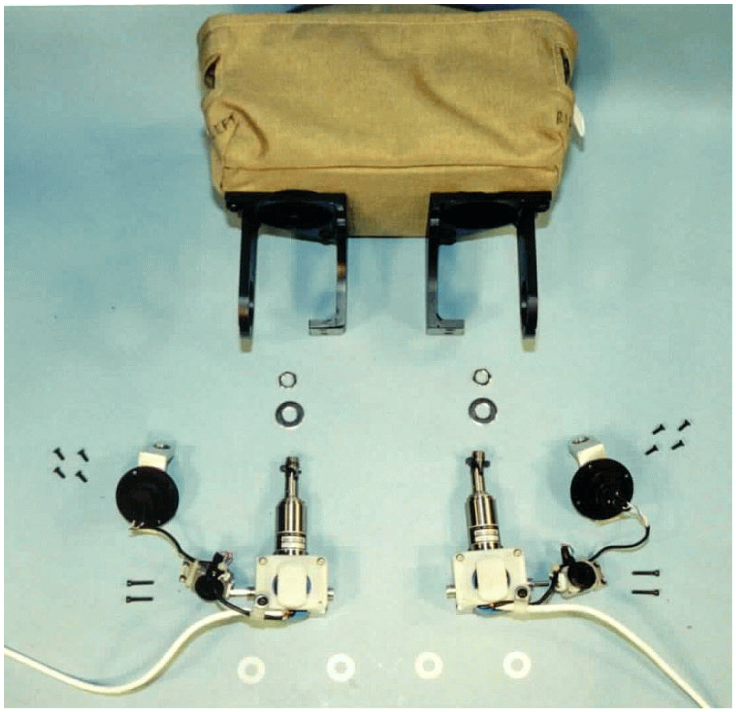

Figure 17.2- Exploded DGSP assembly

17.2.2 Attaching DGSP Units to the Lower Abdomen Assembly

The following assembly procedure is a step-by-step description of how to attach the two DGSP units to the completed lower abdomen assembly. After the units have been assembled onto the lower abdomen mounting bracket, the lower abdomen assembly will be ready for insertion into the THOR dummy. The numbers noted in ( ) refer to a specific drawing / part number for each part. The numbers noted in the { } indicate the hex wrench size required to perform that assembly step. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values.

1. Check the DGSP units for calibration date. If a calibration is due, the units must be calibrated prior to assembly. The calibration procedure is outlined in Section 17.5.

NOTE: The DGSP units must be calibrated prior to insertion in the lower abdomen assembly.

---

2. Identify the left and right DGSP units, noting that the left and right units are assembled differently. The difference relates to the position of the rotary potentiometer #2 in the final mounted position. On their perspective sides, the #2 rotary potentiometers are facing upward on the yoke and gimbal assembly. They are positioned this way to prevent interference with the side support brackets if facing downward. **Figure 17.3** shows the left and right DGSP units for reference.

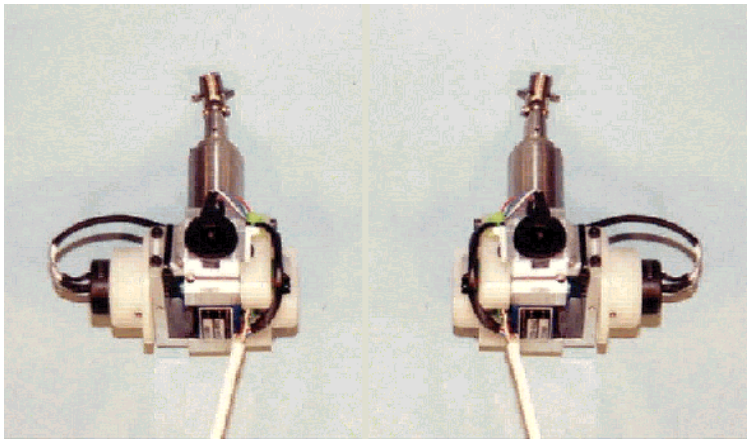

Figure 17.3- Comparison of the left and right DGSP units

3. Locate the Left DGSP Unit (T1DPM000). Remove the two #4-40 x 3/8" SHCS {3/32} that hold the Right Yoke Arm (T1DPM213) to the Left Yoke Arm (T1DPM212) and Gimbal Assembly (T1DPM200), as shown in **Figure 17.4**.

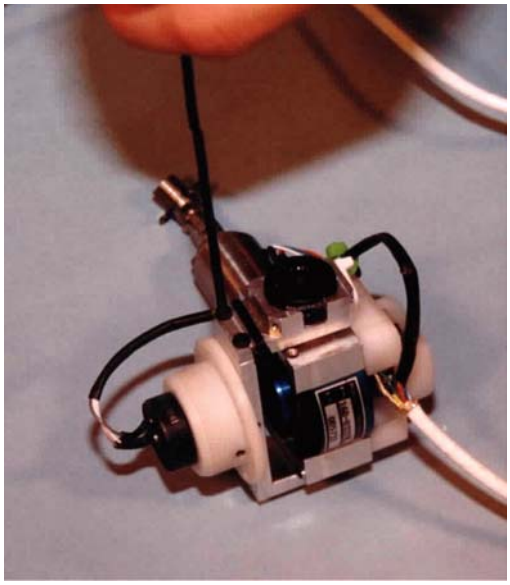

Figure 17.4- Bolt location for disassembly

WARNING: Due to the soldered connections, only a small distance separates the string potentiometer assembly from the yoke left arm. It is important to keep the two assemblies in close proximity to avoid applying tension to the wires.

4. Carefully separate the Rotary Potentiometer #1, DGSP Right Arm and String Potentiometer Assembly (T1DPM300) from the DGSP yoke left arm, as shown in **Figure 17.5**. Two Teflon washers will fall off the lower trunnions of the string potentiometer assembly.

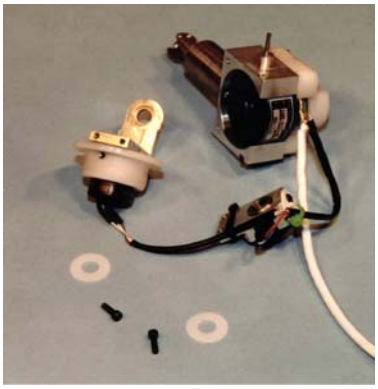

Figure 17.5- DGSP separation

5. Pass the wire which connects Rotary Potentiometer #1 (T1INM210) to the Yoke Axis Rotary Potentiometer (T1DPM210) through the slot in the rear of the Lower Abdomen Attachment Bracket - Left (T1LAW040). The DGSP assembly should be oriented to the inside of the attachment bracket as shown in **Figure 17.6**.

Figure 17.6- Route potentiometer wiring through slot in plate

6. Insert the Left DGSP telescope into the left access hole in the rear of the lower abdominal bag mounting plate, as shown in **Figure 17.7**.

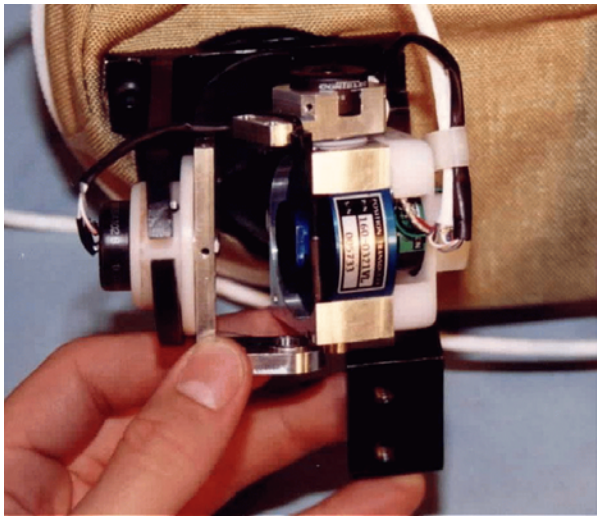

Figure 17.7- Insert telescope into access hole

7. Insert the Rotary Bushing (T1DPM211) and Yoke Axis Rotary Potentiometer (T1DPM210) through the 1.25" diameter hole of the left attachment bracket, as shown in **Figure 17.8**.

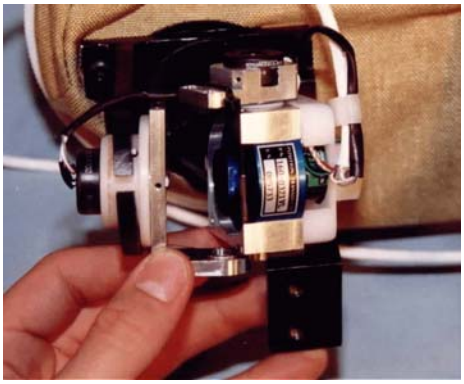

Figure 17.8- Insert bushing into hole in bracket

8. Rotate the flanged surface of the bushing until the engraved arrow is pointing upwards as shown in **Figure 17.9**. The orientation of the arrow will ensure proper operation of the yoke axis rotary potentiometer during the dynamic test event.

Figure 17.9- Proper orientation of the arrow

9. Secure the rotary bushing to the left attachment bracket using four #4-40 x 3/8" FHSCS {1/16}, as shown in **Figure 17.10**. Check to be sure that the engraved arrow is still oriented upwards.

NOTE: There are two patterns of #4-40 holes on the attachment bracket. The bushing will only fit on the bolt pattern with the smaller diameter.

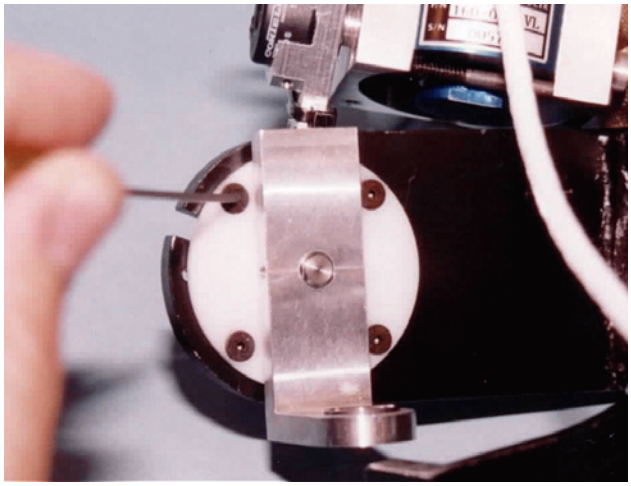

Figure 17.10- Secure the bushing to the bracket

10. Place the Teflon washers onto the lower trunnions of the String Potentiometer Assembly (T1DPM300) and reinsert the trunnion into the bearings of the DGSP yoke left arm. Replace the two #4-40 x 3/8" SHCS that hold the Right Yoke Arm (T1DPM213) to the Left Yoke Arm (T1DPM212) and Gimbal Assembly (T1DPM200), as shown in **Figure 17.11**.

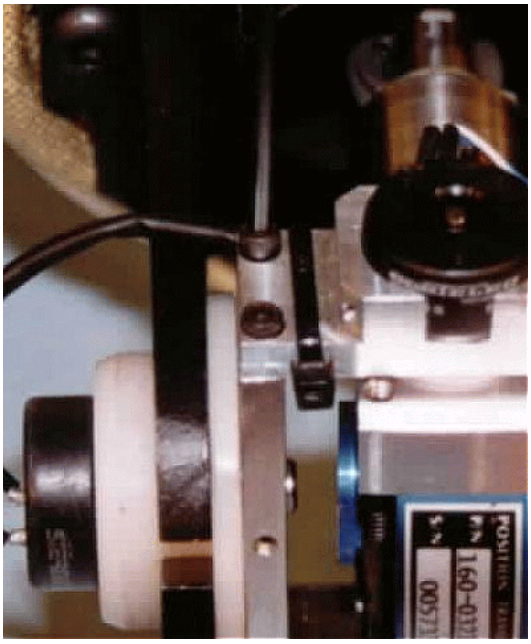

Figure 17.11- Reassembly of the yoke arms and gimbal assembly

11. Place the Potentiometer Cover (T1LAM011) over the exposed terminals of the yoke axis rotary potentiometer, so that the small groove in the cover provides strain relief to the wire. Align the hole pattern of the cover with the pattern on the side support bracket, and secure the covers to the brackets using three #4-40 x 5/8" SHCS {3/32}, as shown in **Figure 17.12**.

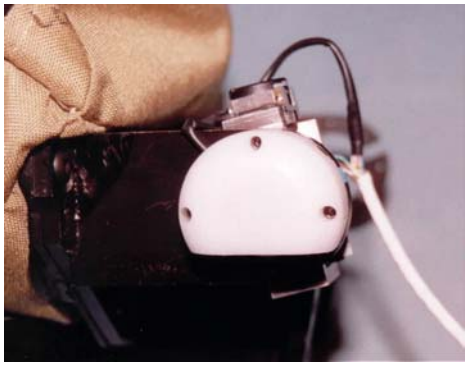

Figure 17.12- Proper positioning of the potentiometer cover

12. Repeat Steps 3 through 11 for the right hand DGSP unit.

13. Ensure the panel nut and stainless steel washer on the DGSP U-joints are removed. Attach the threaded end of a DGSP assembly cable to the tapped hole in the end of each DGSP unit.

14. Align the four ½" diameter bores in the Rear Abdominal Foam Layer (T1LAM013) with the posts protruding from the inside face of the internal mounting plate. Pass the DGSP assembly cables through the large bored holes in the rear foam layer. Press the rear layer of foam over the cones and against the internal mounting plate, as shown in **Figure 17.13**. The foam should be on the inside of the abdominal bag.

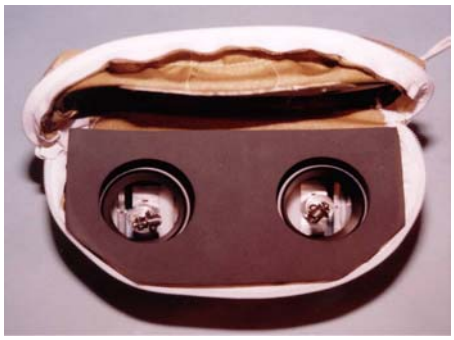

Figure 17.13- Rear foam layer inserted into lower abdominal bag

15. Examine the Front Abdominal Foam Layer (T1LAM012), position the flat face against the exposed surface of the rear foam layer, as shown in **Figure 17.14**. Again, pass the DGSP assembly cables through the large bored holes in the front foam layer.

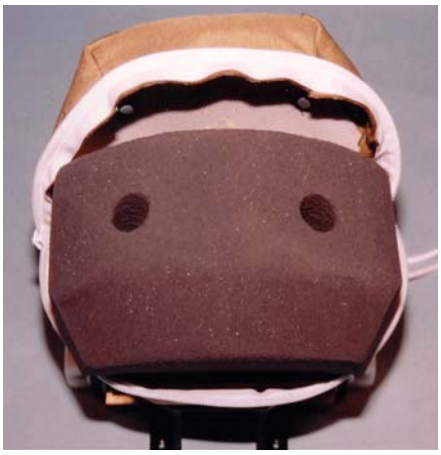

Figure 17.14- Front Abdominal Foam Layer properly positioned

16. Place a Load Distribution Plate (T1LAM014) onto each DGSP assembly cable, as shown in **Figure 17.15**. The small counterbore in one side of the distribution plate must be oriented toward the DGSP assembly. These load distribution plates will rest inside the lower abdomen bag and distribute the tension in the string potentiometer to a large area of the foam.

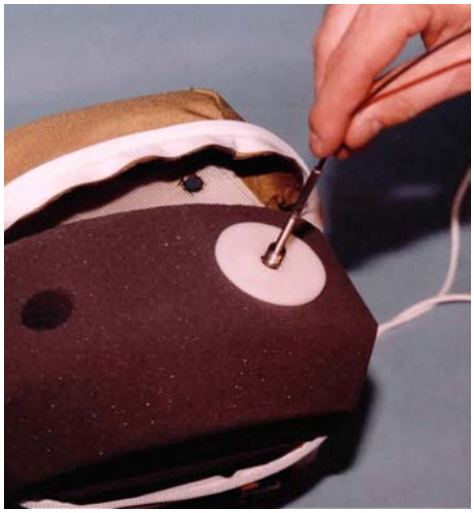

Figure 17.15- Load Distribution Plate assembled on the cable

17. Thread each DGSP assembly cable through their respective holes in the front of the abdominal bag.

NOTE: A good trick is to use a binder clip on the cables to prevent them from accidentally pulling back into the lower abdomen bag.

---

18. Close the lower abdominal bag and adjust the foam within the bag geometry. Zip the bag closed.

19. Thread a stainless steel washer and a panel nut onto each DGSP assembly cable, as shown in **Figure 17.16**.

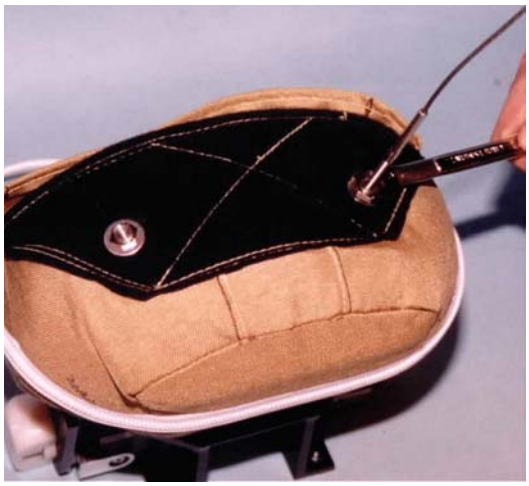

Figure 17.16- Install washer and thread on the panel nut

20. Grasp the left hand DGSP Assembly Cable and pull the DGSP telescope into an extended position. Change the angle of pull as necessary to "steer" the DGSP U-joint through the load distribution washer and lower abdomen bag. Continue holding tension on the cable.

21. Secure the DGSP unit to the front of the Lower Abdomen assembly using the washer and panel nut. Tighten the panel nut {½" crescent wrench} until it is flush with the threaded end of the U-joint.

WARNING: Do not over tighten the DGSP panel nuts. This will cause the U-joints to protrude further than necessary from the lower abdomen assembly.

---

22. Repeat Steps 22 and 23 for the right hand DGSP. The completed DGSP installation is shown in **Figure 17.17**.

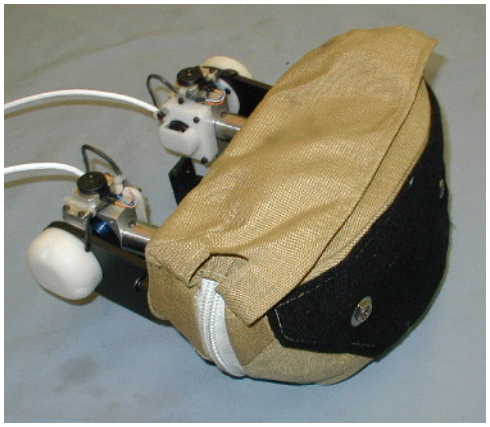

Figure 17.17- Complete DGSP assemblies installed in the Lower Abdomen

17.2.3 Removing the DGSP Units from the Lower Abdominal Assembly

Removal of the DGSP may be required for inspection or maintenance of the units. The simplest way to remove the DGSP is to remove the entire lower abdominal component from the dummy as described in Section 10- Lower Abdomen. Detaching the DGSP units can be accomplished by reversing the steps detailed in Section 17.2.2- Attaching DGSP units to the Lower Abdomen Assembly, with the following notes to aid the process.

WARNING: Do not allow the telescope to recoil too quickly. An unrestrained recoil could damage the transducer!

---

1. The DGSP assembly cables should be threaded into the ends of the U-joints to allow the DGSP units to be guided slowly into the collapsed position.

2. Using a ½" crescent wrench, unscrew the 3/8" thin electronics nut of the U-joint on the outside cover of the lower abdominal bag. Be careful to maintain tension on the DGSP so it does not snap into the unit.

3. When the nut and washer have been removed from the threads of the U-joint, slowly collapse the telescope.

4. Continue the disassembly as described in Section 17.2.2- Attaching DGSP Units to the Lower Abdomen Assembly by reversing the assembly procedure.

17.3 Adjustments for the DGSP units

No adjustment of the DGSP units is required.

17.4 Electrical Connections and Requirements

17.4.1 Wire Routing

The wire routing for the two DGSP units is described in detail below and shown in **Figure 17.18**

Left DGSP Unit: The wires are routed to the left side of the spine and are joined to the wire bundle at the base of the spine.

Right DGSP Unit: The wires are routed to the right side of the spine and are joined to the wire bundle at the base of the spine.

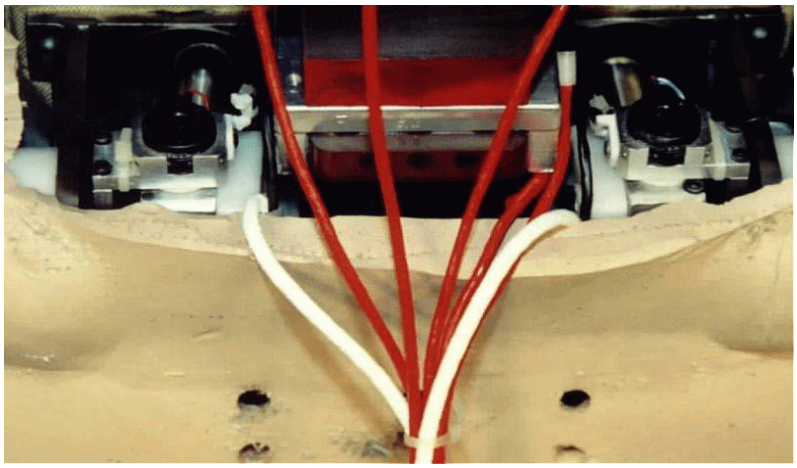

Figure 17.18- Proper wire routing for DGSP wires

17.4.2 CRUX Unit Electrical Connection

Each DGSP unit is wired by the manufacturer with a 15' multi-conductor instrumentation wire. Depending on the dummy application. This wire may be terminated with a set of three high quality, four-pin LEMO connectors for leased units, or a bare end for commercial units. The wire is fully shielded and the shield is passed through the connector.

On the leased dummies, the wires have been broken out into three bundles and the connector wires have the wire color coding as described in Section 15- Instrumentation and Wiring. **Table 17.1** lists the wiring code for commercially sold units.

Table 17.1

Wire Color	Function
Red	Pot #1 (String Pot): +Excitation
Black	Pot #1 (String Pot): Ground
Green	Pot #1 (String Pot): Output
Orange	Pot #2 (Yaw): +Excitation
Black Stripe	Pot #2 (Yaw): Ground
Blue	Pot #2 (Yaw): Output
Red Stripe	Pot #3 (Pitch): +Excitation
Gray	Pot #3 (Pitch): Ground
White	Pot #3 (Pitch): Output

The potentiometers from the DGSP units are designed to be measured as a referenced single-ended channel configuration in which the + Signal lead is connected to a HI input channel of the data acquisition system. The data acquisition system is then configured as a referenced single-ended input to measure the voltage difference between the HI channel input and the ground reference. The DGSP multi-conductor wire is shielded to prevent cross-talk with other instrumentation. The recommended excitation voltage for the DGSP units is 10.00 V DC. Under normal operation conditions, the output signal from any of the three potentiometers should be between 0 and 10 volts DC. A simple voltage check may be used to determine if the potentiometers are outputting a voltage in the expected range of 0 to 10 V DC.

WARNING: The output voltage from the rotary potentiometers should never actually read 0.0 or 10.0 volts. Readings of exactly 0.0 or 10.0 indicate the potential existence of a short in the signal wire to either ground or + excitation.

The DGSP units are designed to be removed and assembled as a complete unit. The disassembly of the individual components which make up a complete DGSP assembly is beyond the scope of this manual. The electrical connections and wiring for the DGSP units are performed during the assembly of the unit by the manufacturer . It is HIGHLY RECOMMENDED that DGSP units which are experiencing electrical problems be returned to the manufacturer for repair. Refer to the THOR drawing package for additional wiring details.

17.5 DGSP Measurement System Calibration

Prior to installing the DGSP units into the thorax assembly, each unit must be calibrated to determine the output voltage for various angular orientations. The calibration of these units is most easily performed on the DGSP Calibration Fixture (T1CME200) which is available for purchase from the manufacturer. This fixture was designed to accurately position the DGSP units into several predefined orientations. The voltage output from each of the potentiometers is measured and recorded for each position to provide an accurate calibration. These voltage outputs are correlated with known angles of the calibration plate and the calibration factor (mV/deg), and initial offsets are calculated for use in the THORTEST. Each DGSP unit is calibrated by the manufacturer upon initial assembly, and may be returned to the manufacturer for recalibration at any time. It is recommended that recalibration be performed after 25 tests have been conducted.

The calibration procedures for the DGSP units are described in the THOR Calibration Manual, which is available from the manufacturer as a separate publication.

NOTE: If at any time during the testing the output of the DGSP units reaches the level of 0.00 (ground) or 10.0 (+ excitation), or if the units have been physically damaged, the units should be removed, inspected, and recalibrated.

17.6 Inspection and Repairs

After a test series has been performed, several inspections may be performed to ensure the dummy's integrity has remained intact. Use good engineering judgement to determine the frequency of these inspections; however, the manufacturer recommends a thorough inspection after twenty tests have been conducted. Inspection frequency should increase if the tests are particularly severe or if unusual data signals are being recorded. Both electrical and mechanical inspections are most easily carried out during a disassembly of the dummy. Disassembly of the DGSP units from the dummy and upper abdomen assembly can be performed by simply reversing the assembly procedure. Some comments are provided below to assist in this process.

17.6.1 Electrical Inspections (Instrumentation Check)

Begin with the visual and tactile inspection of all instrument wires. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure they are properly strain relieved. A more detailed check on the individual instruments is covered in Section 15 - Instrumentation and Wiring.

17.6.2 Mechanical Inspection

The DGSP units will require a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact the manufacturer regarding items which fail mechanical inspection.

DGSP Units: The following checklist should be used when inspecting the dummy's DGSP units for post-test damage:

- Check tightness of lower abdomen connection nuts
- Inspect the lower abdomen foam for permanent compression caused by DGSP cable tension. Procedures to relieve this tension are described in Section 2.4 and 2.8

In addition, a more detailed inspection can be conducted if the units are removed. (Removal is not recommended unless a problem is suspected.)

- Inspect the Universal joint end to ensure it moves freely.
- Inspect the extension and retraction of the telescopic column to ensure free sliding motion. The DGSP unit should retract forcefully under its own tension without binding or hesitation.
- Inspect the potentiometers and joints for physical damage which may indicate contact between the DGSP units and another assembly.
- Inspect the telescopic column of the DGSP units for physical damage.
- Inspect the wiring for physical damage including broken connectors, pinched wires, missing insulation, etc.

If any damage is found during the inspection of the DGSP units, the damaged unit(s) should be returned to the manufacturer for repair or replacement. Due to the complicated nature of the DGSP units, the disassembly and repair of individual components of each DGSP are beyond the scope of this manual. Contact the manufacturer's Engineering Department if further disassembly or inspection is required.